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TITLE: Decoding method for trellis codes with large free distances

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CLAIMS:

What is claimed is:

1. A decoding method for a trellis code T of which the encoding can be implemented by first using an encoder of a binary trellis code C.sup.(1) to encode an r-bit message u(t) into an intermediate binary m-tuple v.sup.(1) (t) at a t-th time unit which is sequentially converted into binary m-tuples v.sup.(2) (t), . . . , v.sup.(L) (t) and a signal point v.sup.(L+1) (t) in a signal space .OMEGA. through L (L.gtoreq.2) processors, comprising the decoding steps of:

(a) at a (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(L))-th time unit, a processor P.sup.(L) determining a set T.sub.M.sup.(L) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(L-1)) which consists of 2.sup.m metrics for the 2.sup.m possible values of v.sup.(L) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(L-1)), based on part of the set {y(t+i): i.ltoreq..LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(L) } and part of the set {v.sup.(L) (t-j): j.gtoreq..lambda.}; feeding the metric set T.sub.M.sup.(L) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(L-1)) into a processor P.sup.(L-1) ; wherein y(t+i) is a received symbol to be decoded, .LAMBDA..sup.(1), . . . , .LAMBDA..sup.(L) are nonnegative constants and .lambda. is a truncation length to be used in decoding C.sup.(1) ;

(b) for l=L-1, L-2, . . . ,1, a processor P.sup.(l) determining a set T.sub.M.sup.(l) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(l-1)) which consists of 2.sup.m metrics for the 2.sup.m possible values of v.sup.(l) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(l-1)) based on part of {T.sub.M.sup.(l+1) (t+i): i.ltoreq..LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(l) } and part of the set {v.sup.(l) (t-j): j.gtoreq..lambda.}; feeding the metric set T.sub.M.sup.(l) (t+.LAMBDA..sup.(1) + . . . +.LAMBDA..sup.(l-1)) into a processor P.sup.(l-1) ; wherein .LAMBDA..sup.(l) is a nonnegative constant;

(c) a processor P.sup.(0) recovering the transmitted symbol u(t-.lambda.+1) and v.sup.(1) (t-.lambda.+1) by applying the Viterbi decoding algorithm to the trellis of C.sup.(1) and using part of the set {T.sub.M.sup.(1) (t-i): i.gtoreq.0}; feeding back the recovered v.sup.(1) (t-.lambda.+1) to P.sup.(1) ;

(d) for l=1,2, . . . ,L-1, P.sup.(l) processing the set {v.sup.(l) (t-j): j.gtoreq..lambda.-1} and determining v.sup.(l+1) (t-.lambda.+1) which is then fed back to P.sup.(l+1) .

2. A decoding method as in claim 1, wherein the encoder of said single binary trellis

code C.sup.(1) is replaced by the encoders of a plurality of binary trellis codes which together convert u(t) into v.sup.(1) (t)=(v.sub.1.sup.(1) (t), v.sub.2.sup.(1) (t), . . . , v.sub.m.sup.(1) (t)), which is then processed by L multilevel delay processors and L signal mappers; and wherein said Viterbi decoding algorithm for C.sup.(1) used in the processor P.sup.(0) is replaced by a plurality of Viterbi decoding algorithms for said plurality of binary trellis codes.

3. An decoding method as in claims 1 or 2, wherein the encoding of said trellis code T can be implemented by the steps of:

i) using the encoder of a single binary trellis code C.sup.(1) to encode an r-bit message u(t) at the t-th time unit so as to obtain an m-bit output v.sup.(1) (t)=(v.sub.1.sup.(1) (t),v.sub.2.sup.(1) (t), . . . ,v.sub.m.sup.(1) (t));

ii) processing said output of the encoder through a multilevel delay processor Q.sup.(1) to obtain a processed output s.sup.(1) (t)=(s.sub.1.sup.(1) (t), s.sub.2.sup.(1) (t), . . . , s.sub.m.sup.(1) (t)) such that ##EQU11## wherein .lambda..sub.1.sup.(1), .lambda..sub.2.sup.(1), . . . , .lambda..sub.m.sup.(1) are nonnegative constants;

iii) feeding said output of Q.sup.(1) into a signal mapper S.sup.(1) to select a signal point w.sup.(1) (s.sup.(1) (t))=v.sup.(2) (t)=(v.sub.1.sup.(2) (t),v.sub.2.sup.(2) (t), . . . ,v.sub.m.sup.(2) (t));

iv) for l=2, 3, . . . , L, feeding the output v.sup.(l) (t) into a multilevel delay processor Q.sup.(l) to obtain a processed output s.sup.(l) (t)=(s.sub.1.sup.(l) (t),s.sub.2.sup.(l) (t), . . . ,s.sub.m.sup.(l) (t)), such that ##EQU12## wherein .lambda..sub.1.sup.(l), .lambda..sub.2.sup.(l), . . . , .lambda..sub.m.sup.(l) are nonnegative constants, and then feeding s.sup.(l) (t) into a signal mapper S.sup.(l) to select a signal point w.sup.(l) (s.sup.(l) (t))=v.sup.(l+1) (t), whereby if 14. A decoding method as in claim 3, wherein the parameter .lambda..sup.(l) of the processor P.sup.(l) is no less than .SIGMA..sub.i=1.sup.m .lambda..sub.i.sup.(l) for 1.ltoreq.l.ltoreq.L.

5. A decoding method as in claim 3, wherein said constants .lambda..sub.1.sup.(l), .lambda..sub.2.sup.(l), . . . , .lambda..sub.m.sup.(l) are distinct values and/or at least one of the constants .lambda..sub.1.sup.(l), .lambda..sub.2.sup.(l), . . . , .lambda..sub.m.sup.(l) is not zero.

6. A decoding method as in claim 3, wherein said constants .lambda..sub.1.sup.(l), .lambda..sub.2.sup.(l), . . . , .lambda..sub.m-1.sup.(l) are all identical to a constant .lambda..sup.(l) and .lambda..sub.m.sup.(l) =0.

7. A decoding method as in claims 1 or 2, wherein said binary trellis code or a plurality of binary trellis codes is/are a linear and time-invariant code or a plurality of linear and time-invariant codes respectively, i.e., a binary convolutional code or a plurality of binary convolutional codes.

8. A decoding method as in claims 1 or 2, wherein the signal space .OMEGA. is a signal constellation; then said method can be used to decode trellis coded modulation.

9. A decoding method as in claims 1 or 2, wherein the signal space .OMEGA. is a collection of binary m-tuples; then said method can be used to decode binary trellis codes.

10. A decoding method as in claims 1 or 2, wherein the r-bit information, u(t), represents m/m.sup.(1) binary (r.multidot.m.sup.(1) /m)-tuples, whereby m.sup.(1) is a positive integer.

11. A decoding method as in claims 1 or 2, wherein the binary m-tuple v.sup.(l) (t), 1.ltoreq.l.ltoreq.L, can be decomposed into m/m.sup.(l) binary m.sup.(l) -tuples, wherein m.sup.(l) is a positive integer; and v.sup.(L+1) (t) represents m/m.sup.(L+1) signal points in .OMEGA. which consists of 2.sup.(m.spsp.(L+1).sup.) signal points, wherein m.sup.(L+1) is a positive integer.